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ABSTRACT

Twenty-five male (aged 7 years, 6 months to 10 years, 7 months) and five female (aged 9 years, 3 months to 10 years, 2 months) minimally brain damaged children were examined to determine feasibility of perceptual motor training on the pursuit rotor (which requires Ss to track a light as it revolves under a pattern on a turntable). Experimental Ss matched on performance IQ, hand dominance, sex, and chronological age with control Ss were randomly assigned to one of three training groups in which, after two trial runs with the nonpreferred hand to establish baseline, they traced angular, circular, or both angular and circular patterns respectively on the pursuit rotor in eight training sessions. Reinforcement was given in sessions two through eight. Data from such tests as the Bender Visual Motor Gestalt Test and the Koppitz Developmental Scoring System revealed that there were no significant differences between Ss on pretests, that training on the pursuit rotor has specific transfer to figure copying tasks in general, and that the act of training perceptual motor skills is the important variable rather than the specific pattern on which the training is given. (MC)

TRAINING OF PERCEPTUAL MOTOR SKILLS IN MINIMALLY BRAIN DAMAGED CHILDREN[1]

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Certain learning or behavioral disabilities ranging from mild to severe are often the result of minimal cerebral dysfunction. Such damage may manifest itself through combinations of impairment in perception, motor activity, and other cognitive functions, and may be found in children at all levels of intellectual functioning. One area which has attracted considerable attention is that of perceptual-motor deficits, due primarily to the fact that this function is related to the lack of readiness for school learning. Visual motor perception, for example, is thought to be an integral part of learning to form letters or words, and in learning to read.

The disturbance in the operations of the perceptual-motor process may occur at any point in the process: in the sense organs, the integrative process, or in the response process (Strauss, 1955). The brain damaged child is often able to perceive parts of a figure but is unable to combine them into a whole. For example, if asked to reproduce a square, the child may leave the corners unconnected. He responds to a detail of the stimulus configuration, fails to reconstruct the whole, and appears to be more aware of the particular portions of the figure which initially attracted his attention. It should be noted that many children manifest deficits in more than one aspect of the process, and it is often difficult to differentiate between the areas in which the damage has occurred.

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Frostig (1962) maintains that distinct functions of visual perception can be disturbed independently (in varying degrees) and has identified five areas which are thought to be critical for the acquisition of school learning: eye-motor coordination, figure-ground perception, form constancy, position in space, and spatial relations. Furthermore, she believes that perceptual training can be directed toward the particular functions disturbed to remedy perceptual deficiencies. In training eye-motor coordination, the youngster begins by tracing lines between wide boundaries with his finger, then draws curved and angled lines between narrow limits with a pencil, and finally proceeds to the formation of letters. Exercises requiring gross and fine body movements are also included.

In the area of eye-hand coordination, Getman (1966) has also investigated the training of pursuit eye movements. His tasks include following a thumbnail as the child moves it laterally, and chalkboard routines in which the child draws bilateral circles, squares, etc. These exercises give the child an opportunity to learn how to use his eyes and hands as a team in manipulating tools for forming the symbols of written language. Getman also suggests that visual form perception can be trained through elementary, gross, or general movement activities such as walking the perimeter of a geometric figure, or using eyes and hands to trace and reproduce forms. Such exercises develop figure-ground discrimination, perception of size, and perception of differences.

The sense of touch is also considered to be important to

effective motor behavior and is frequently underdeveloped in the minimally brain damaged child. Factual and manipulative expressions are important to the development of visual space and are seen to occur prior to the visual percept. Thus in training visual motor perception, manipulative tasks should be included in conjunction with visual tasks (Cruickshank, 1961).

One popular instrument used for assessing and diagnosing the presence of perceptual-motor deficits in children is the Bender Visual Motor Gestalt test (Bender, 1938; Pascal, 1951; Koppitz, 1964). The Bender Gestalt test consists of nine figures which are presented one at a time and which the subject is asked to copy on a blank sheet of paper. Bender maintains that reproduction of the figures is determined by the child's sensory motor ability. If a training program for visual motor perception were devised, this task could be used to assess the effects of training in visual motor perception.

One method of quantitatively analyzing the Bender Gestalt test is the Koppitz Developmental Bender Scoring System. This scoring system consists of 30 mutually exclusive scoring items which are scored either present or absent and which are added into a composite score. It has provided a way of analyzing the Bender protocols of young children to provide evaluations of perceptual maturity, possible neurological impairment, and emotional adjustment. Koppitz found that children with neurological impairment rarely have above average scores on the Bender. In addition, Bruner and Gillman (1968) demonstrated that her scoring system could differentiate between normal Ss and a group

of children with both visual-motor disorders and educational problems.

Indicators of brain damage within the Bender using the Koppitz system are expressed as distortion scores, which are essentially manifestations of poor visual motor coordination. The deviations which are considered the primary indications of brain damage include: (1) rotation - the disorientation of the whole figure, or any part of it; (2) perseveration - the repetition of the whole figure, or any part of it; (3) difficulty in placing parts of figures at correct angles; (4) distortion of the figure; (5) fragmentation; (6) poor integration; and (7) substitution of lines for dots. The inability to reproduce angles and distortions of the simple figures of the Bender are consistently important in the prediction of minimal brain damage in eight to ten year olds (Koppitz, 1964; Wierner, 1966). It should be noted, however, that all children show the seven diagnostic deviations at some stage in their development. It is only when the child is well past the age when the distortion is normal that, according to Koppitz, it becomes an indicator of neurological impairment. As a consequence, the number of Bender scoring items which differentiate between the normal and the brain damaged child, increases as the age of the child increases. Koppitz's neurological indicators are therefore, a subset of the developmental score.

Another task that is used to assess brain damage is the Benton Visual Retention test (Benton, 1963). In this task, there may be more than one figure on a card and S is required

to reproduce the figure either while the card is before him, after a five or ten second exposure to the figure, or after a ten second exposure with a fifteen second delay. In scoring the Benton, in addition to getting a total error score, errors are categorized by visual field which are thought to give some indication of localization of damage.

A relationship has also been demonstrated between Bender protocols (as scored by Koppitz) and other figure copying tasks. Culberton (1966) found that there was consistency in the performance of brain damaged children on the Bender and the figure copying task of the Frostig program. Such findings suggest that tasks similar to figure copying may be useful in training the brain damaged child. One such task employs the pursuit rotor which has been used in psychology to study motor learning. This task is similar to figure reproduction in that S is required to track a light as it revolves under a pattern on a turntable. Since this task employs gross motor skills, it may be used for training perceptual motor skills in brain damaged children. As described by Huse (1965), there are advantages in using the pursuit rotor task for investigation of special groups of children. Performance on this instrument is less sensitive to socio-educational factors than many tasks; psychological parameters governing performance have been investigated; and performance on this and similar tasks might provide information for diagnosis and rehabilitation.

With these factors in mind, a study was designed to determine the feasibility of training minimally brain damaged children

on the pursuit rotor. This task was selected because it provides $\underline{S}$ with immediate and continuous knowledge of his accuracy throughout each learning trial instead of after the total sequence has been completed (Adams, 1969). Training was given on a number of patterns under the assumption that practice with these patterns would yield specific transfer to similar patterns on the Bender. It was predicted that practice (with the preferred hand) on various pursuit rotor patterns would result in a reduction in deviation scores on the Bender as scored by the Koppitz Developmental Scoring System. Bilateral transfer (to the nonpreferred hand) was also assessed to test the hypothesis that a positive correlation would exist between amount of transfer and number of errors in the nondominant visual field as indicated by scores on the Benton.

METHOD

Subjects

Subjects were 30 children (25 M and 5 F) from two schools for the brain damaged: Midland School in North Branch, New Jersey and Pathways School in Audubon, Pennsylvania. The female _Ss_ were between the ages of 9 years 3 months and 10 years 2 months, and the males were between the ages of 7 years 6 months and 10 years 7 months. Twenty-one _Ss_ were right handed and nine were left handed.

Apparatus

The Polar Pursuit Tracker, Model PR 15 (Research Media, Incorporated), was employed. Attached to the tracker were a stop clock for recording _S_'s time on target (TOT) and an impulse counter recording the number of revolutions. A stop watch was used to time the inter-trial interval (ITI). There were four target patterns: square (S), triangle (T), circle (C), and ellipse (E).

Procedure

A transfer design was employed with the experimental and control groups matched on the developmental score of the Bender pretest, the Wechsler Intelligence Scale for Children - performance IQ (PIQ), hand dominance, sex, and chronological age (CA). _Ss_ from each matched pair were randomly assigned to the experimental or control group. _Ss_ in the experimental group were then randomly assigned to one of three training groups: Group I traced angular patterns on the pursuit rotor, Group II

traced circular patterns, and Group III traced both sets of patterns.

The experimental Ss were given 8 training sessions (instructions to Ss appear in Appendix A). Prior to session one, each S was run for two trials with the nonpreferred hand to establish a baseline for later assessment of bilateral transfer. Each of the first six training sessions was conducted with the preferred hand and consisted of 10 one minute trials (15 second ITI) with the pursuit rotor set at 30 rpm. During the last two training sessions, the Ss used the preferred hand for five trials and the nonpreferred hand for five trials. The design is summarized in Table 1.

During the first training session no reinforcement was given. On sessions 2-8 reinforcement (consisting of small packages of candy and pretzels) was given if performance improved over the initial trial of that session. All subjects were then given the Bender and the Benton Visual Retention Test as a posttest. The Bender was administered to each group following Koppitz' procedure and using her instructions to Ss. Form C of the Benton was used with Administration A in which S is asked to reproduce the figure after a ten second exposure to the card.

TABLE 1

Experimental Design

Groups	Pretest Bender	Patterns for baseline trials 1	2	Patterns for training sessions 1	2	3	4	5	6	7	8	Posttest Bender & Benton
Experimental												
I. Angles	Pretest	T	T	T	S	T	S	T	S	T	S	Posttests
II. Circles	Pretest	C	C	C	E	C	E	C	E	C	E	Posttests
III. Angles & Circles	Pretest	S	S	S	C	T	E	S	C	T	E	Posttests
Control	Pretest	-	-	-	-	-	-	-	-	-	-	Posttests

RESULTS

Matching Variables

Means and standard deviations for experimental and control groups on C.A., PIQ, and Bender pretest are presented in Table 2. The τ values for differences between experimental and control group means were computed and are also reported in Table 2. Inspection of this table reveals that these groups were not significantly different on any of the three variables. In addition, males and females were equally divided between the experimental and control groups, as was S's hand preference. Furthermore, the three experimental groups were examined and found to be roughly the same on the matching variables.

Pursuit Rotor Training

Mean TOT for each pattern on the eight training sessions for the three experimental groups are presented in Figures 1, 2, and 3. (Since the nonpreferred hand was used for the last five trials on sessions seven and eight, the first five training trials for each session were used in graphing TOT in order to compare performance across all eight training sessions.) Inspection of Figures 1 and 2 indicates that in general TOT increased as a function of practice for all patterns with occasional drops in performance during the last two sessions. There is evidence of increased TOT over trials on Figure 3, but one cannot draw any conclusions since the Ss had only two sessions on each pattern.

TABLE 2

Means, Standard Deviations and τ Values on Matching Variables for Experimental and Control Groups

Variables	Control $\bar{X}$	Control SD	Experimental $\bar{X}$	Experimental SD	τ value (df=14)
Age	9.30 yrs.	.94 yrs.	9.75 yrs.	.57 yrs.	-1.48
PIQ	92.53	12.98	97.67	17.42	- .70
Bender Pretest	5.60	3.26	5.00	2.45	.75

*p<.05

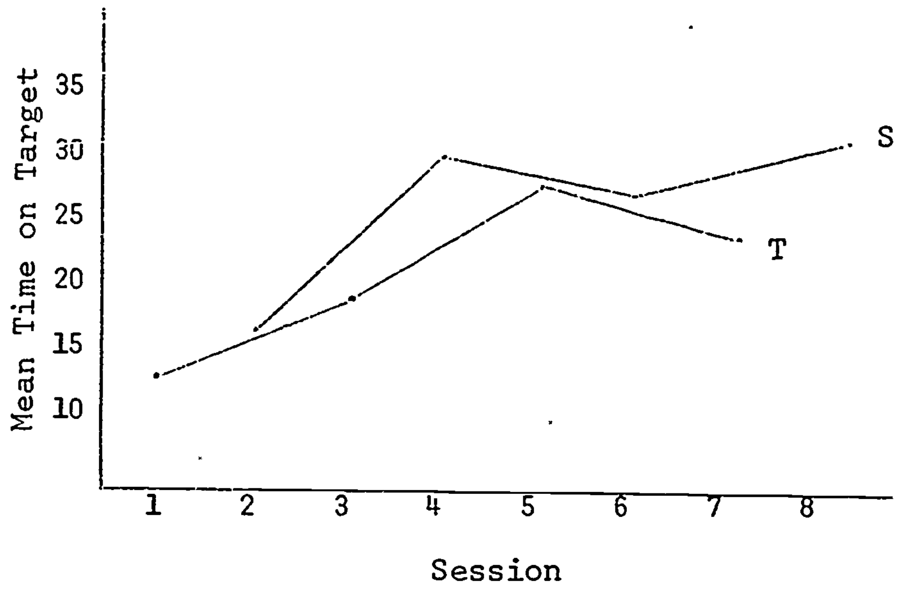

Figure 1. Mean Time on Target (first five trials) for each training session for the first experimental group.

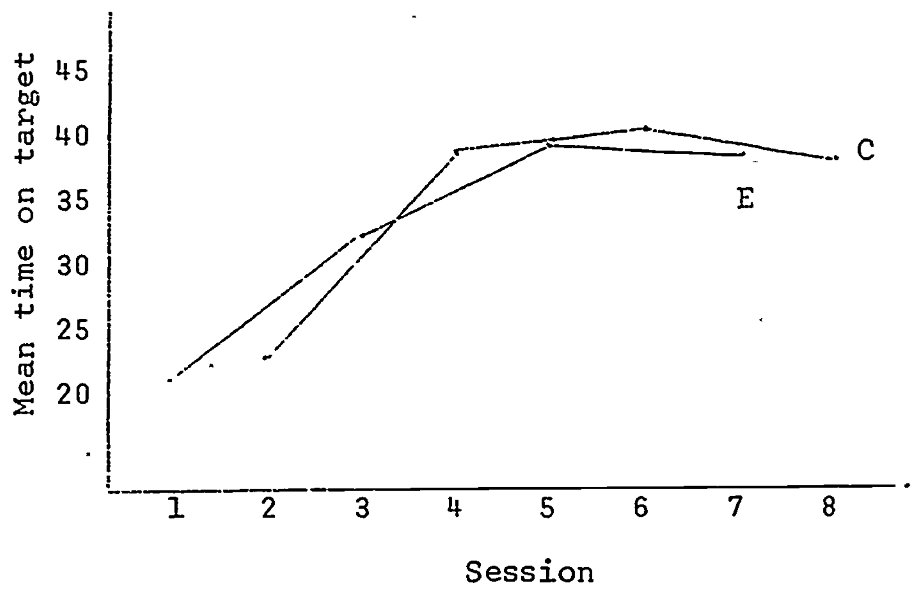

Figure 2. Mean Time on Target (first five trials) for each training session for the second experimental group.

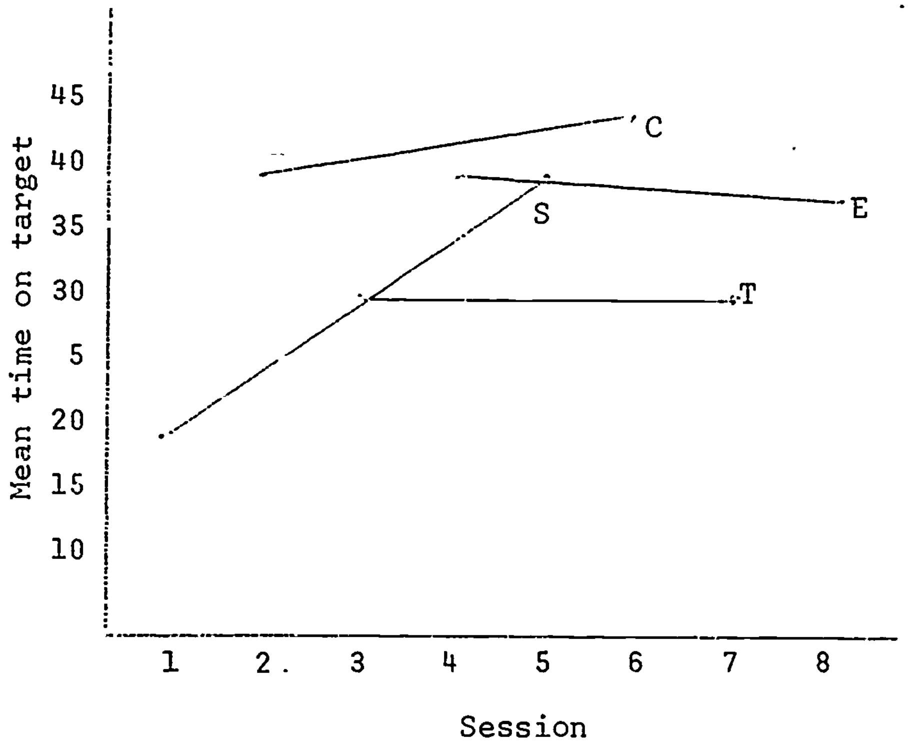

Figure 3. Mean Time on Target (first five trials) for each training session for the third experimental group.

Bender Difference Scores

To determine the reliability of the two independent raters a Spearman coefficient of rank correlation between Developmental Bender scores was calculated. A correlation of .88 suggests that the two raters agreed on the use of the scoring system (consistent with the reliability studies of Koppitz, 1964 and Miller et al., 1963).

Performance for the experimental group significantly improved between pretest and posttest Bender reproductions (τ=5.53, df=14, p<.001). Means and standard deviations for the difference scores and τ values for the Developmental Bender scores are found in Table 3.

To distinguish between Developmental Bender difference scores for each of the three experimental groups, a Kruskal-Wallis test was performed (Siegel, 1956, p. 184). The results indicate that there were no significant differences in errors among the three experimental groups as a result of training on different patterns (H=3.49, p>.05).

Neurological indicators were examined next to determine whether training affected those indicators that are termed neurological. The means, mean difference scores, and standard deviation of the differences for the subset of significant neurological indicators on the Bender are found in Table 4. There was no significant difference between pretest and posttest scores for the control group or the experimental group. As expected, the experimental group's errors were less than those of the control group.

Bilateral Transfer

Means, standard deviations, and the resulting τ value between baseline and transfer scores are found in Table 5. As can be seen there is evidence of significant bilateral transfer. A correlation coefficient was computed between amount of bilateral transfer and the number of errors on the Benton in the nondominant field. The hypothesis that a positive correlation would exist was not supported. In addition, there was no significant correlation between amount of transfer and total Benton errors (-0.14).

TABLE 3

Developmental Bender Scores

Group	Bender pretest mean	Bender posttest mean	Mean difference	$S_{\bar{D}}$	τ value (df=14)
Experimental	5.00	4.07	-.93	.09	-10.35**
Control	5.60	6.27	.67	.35	5.35**

**p<.01

TABLE 4

Bender Scores on Neurological Indicators

Group	Bender pretest mean	Bender posttest mean	Mean difference	$S_{\bar{D}}$	τ value (df=14)
Experimental	4.20	3.47	-.73	.41	1.79
Control	4.13	4.53	.40	.27	1.47

*p<.05

TABLE 5

Baseline and Transfer Phase Performance

Group	Baseline mean	Transfer mean	Mean difference	$S_{\overline{D}}$	τ value (df=14)
Experimental	11.77	20.32	8.53	2.41	3.54**

**p<.01

DISCUSSION

The data support the hypothesis that training on the pursuit rotor will have specific transfer to figure copying tasks in general. It was also hypothesized that there would be a differential effect on Bender scores as a result of training on specific patterns. As indicated by the results of the Kruskal-Wallis test, this was not supported. It is concluded that the act of training perceptual motor skills is the important variable rather than the specific pattern on which training is given.

This conclusion is complicated, however, by the fact that the control group increased in errors significantly on Bender posttest scores. Koppitz found a great deal of variability in test-retest scores for brain damaged children. But there is no experimental evidence that would predict a significant decline in performance. One factor that may have affected the control group is that E had developed better rapport with the experimental group than with the control group, although these children are used to being tested frequently by psychologists and are generally aware of the importance of doing their best. To avoid this problem, the control group could be required to participate with E in an unrelated intervening activity. Another factor that the present study did not control for was the effect of poor posture on the ease of learning the pursuit rotor task. Harmon (1949) indicated that postural imbalance can have a negative effect on visual-motor performance. In his study, Ss who exceeded the tolerance level for stress on posture and other balancing mecha-

nisms showed distortions on drawing squares. In the present study, no arrangements were made to insure that shorter children would stand correctly while tracking. Future studies should control for this variable.

The fact that neither group differed significantly between pretest and posttest measures on neurological indicators may indicate that short time training on the pursuit rotor primarily affects those distortions which are not considered important indicators of brain damage by Koppitz. Since test-retest reliability of the Koppitz neurological indicators has not been found to be highly reliable (Goff and Parker, 1969), additional data is needed before definitive conclusions regarding these results can be drawn.

Further research might also consider changing the length of the training period. Ss verbalized boredom with the task around the sixth day after reaching optimum level of performance. This may have had a negative effect on subsequent training.

In conclusion, the evidence suggests that tracking tasks could be included as part of a perceptual-motor training program in an effort to train gross eye-motor coordination. Proficiency in gross motor areas may be expected to yield positive transfer to fine visual-motor coordination activities including drawing and writing.

FOOTNOTES

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APPENDIX A

INSTRUCTIONS FOR THE PURSUIT ROTOR TASK

This game shows how well you move your hands. This is what you should try to do. When the light begins to move, you try to keep the pointer on the light. At the same time try not to go on the gray area outside the figure (E demonstrates). After I turn the light off, there is a short rest and we will do it again. The score is shown here on this clock. The longer you keep the pointer on the light the higher your score. We will do it 12 times today and then 10 on the next eight days.